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| 10/627,775 | 07/28/2003 | Stuart D. Hellring | 1780A1 | 5341 |

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PPG Industries, Inc.
Law-Intellectual Property-39S
One PPG Place
Pittsburgh, PA 15272

| EXAMINER |
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NGUYEN, GEORGE BINH MINH

| ART UNIT | PAPER NUMBER |
|----------|--------------|
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3723

DATE MAILED: 09/09/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

10/627,775

Applicant(s)

HELLRING ET AL.

Examiner

George Nguyen

Art Unit

3723

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --
Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 20 June 2005.
- 2a) ☒ This action is **FINAL**. 2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-29 is/are pending in the application.
- 4a) Of the above claim(s) 21-23 is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1-20 and 24-29 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
 2. ☐ Certified copies of the priority documents have been received in Application No. _____.
 3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- | | |
|--|---|
| 1) <input type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152) |
| 3) <input type="checkbox"/> Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date _____ | 6) <input type="checkbox"/> Other: _____ |

DETAILED ACTION

Receipt is acknowledged of Applicant's amendment filed on June 20, 2005.

Claims 21-23 were withdrawn from further consideration. Claims 1-20 and 24-29 are presented for examination.

Specification

1. The specification is objected to as failing to provide proper antecedent basis for the claimed subject matter. See 37 CFR 1.75(d)(1) and MPEP § 608.01(o). Correction of the following is required: the examiner was not able to find any support in the specification the functional limitations of "wherein said barrier is not completely removed by said slurry system". For example, on page 3, lines 16-18, the specification discloses only that "the second polish at least partially removes the metal residual remaining on the substrate after the first polish". On page 13, the specification discloses that "the second slurry ... can be used to remove the residual copper remaining on the substrate following termination of the first polishing step with the first slurry. Nowhere else the examiner could find any discussions about "said barrier is not completely removed by said system".

Claim Rejections - 35 USC § 102

1. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

Art Unit: 3723

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

2. Claims 1, 2, 3, 4, 5, 6, 10, 12, 13, 17, 18, 19, 20, 24, 25, 26, 27, 28, and 29 are rejected under 35 U.S.C. 102(b) as being anticipated by Watts et al.'5,985,748.

With reference to col. 3-4, Watts discloses the claimed invention including:

- a first step using a first slurry containing an abrasive component and a chemical component.
- a second step using a second slurry having a reduced amount of the abrasive component.
- the method is carried out with respect to metal (39), such as copper, deposited on a dielectric layer (34) and the first polishing step is stopped before the entirety of the metal overlying the dielectric layer is removed. In one embodiment, the second slurry has no abrasive.

Please note that claims 1-20 are directed to a system or an apparatus which must be distinguished from the prior art in term of structure rather than functions [MPEP 2114]. Hence the functional limitations of "wherein said barrier layer is not completely removed by said slurry system" which are narrative in form have not been given any patentable weight. In order to be given patentable weight, a functional recitation must be supported by recitation in the claim of sufficient structure to warrant the presence of the functional language. In re Danly, 263 F. 2nd 844, 847, 120 USPQ 528, 531 (CCPA 1959).

5,985,748

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vias 36 are confined and make electrical contact only in the vertical direction.

The metal is copper according to the embodiment shown, but may be aluminum or tungsten. In each case the metal is put down in layer form on the order of 3,000 to 11,000 angstroms in thickness. When copper is used, a conformal tantalum nitride (Ta₃N₅) film (100 to 500 angstroms) is first sputtered in order to improve adhesion of the copper and to provide a barrier to prevent unwanted diffusion of the copper into the dielectric material.

Turning to FIG. 2, CMP is carried out to remove that portion of the metal 39 above trenches 38a such that the trenches 38a form separate interconnects 38, and the exposed surface of the semiconductor device is polished and planarized for subsequent deposition steps, such as higher-level metal interconnects. Following CMP, it is seen that the fine pitch dielectric portions 34a and interconnects 38 are eroded by depth X. In addition, interconnects 38 are recessed by depth Y. As recognized by the present inventors, the cumulative effect of the recessing and the erosion has a negative impact on the final device characteristics, by increasing line resistance of the finished semiconductor device. In addition, the variance in the topography features shown in FIG. 2 is projected into further layers deposited thereon. For example, after a subsequent dielectric layer is deposited so as to cover the third ILD layer 34, the surface features shown in FIG. 2 are mirrored in the thus deposited layer, and such variance in topography features may result in undesirable metal stringers, which are difficult to remove during subsequent CMP, and which may cause electrical shorts in the finished semiconductor device.

Having recognized the deficiencies with the single step CMP process used in connection with the device shown in FIG. 2, the present inventors have developed a combination-step CMP process, wherein, after depositing metal 39, first and second CMP steps are executed. In general terms, following deposition of metal 39, a first CMP step is carried out utilizing a slurry containing a chemical component (generally, a chemical oxidizer) and an abrasive component that is present at a relatively high concentration, such as approximately 2-15% by weight. An appropriate chemical oxidizer may be chosen by one of ordinary skill in the art for the particular metal composition being planarized. In connection with CMP of copper, the slurry composition described in detail in co-pending patent application Ser. No. 08/954,191 by Watts et al. (Attorney Docket No. SC90482), filed Oct. 31, 1997, may be utilized. As described therein, a chemical oxidizer component may include an oxidizing agent such as hydrogen peroxide and coordinating ligands for copper, and the abrasive component may be alumina. The subject matter of this co-pending application is herein incorporated by reference.

According to an embodiment of the present invention, the first CMP step is carried out to planarize metal 39, but to leave a thin metal layer 39a that overlies the third ILD layer 34, as shown in FIG. 3. It is noted that the thin metal layer includes a portion of the original copper metal and the Ta₃N₅ barrier layer noted above, and has a thickness of approximately 200 to 3000 angstroms, preferably approximately 1000 angstroms. Prior to polishing to the depth of third ILD layer 34, which would expose the third ILD layer 3, the first step is terminated, and the polishing is continued with a second slurry having a chemical component (generally, a chemical oxidizer) and a much lower solids content of abrasive particles (which have a propensity to remove the dielectric layer), such as not greater than 1% by weight. The switch from first step to second step may be abrupt

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(preferred) or transient (i.e., gradual transition from one to the other). That is, a first portion of the metal is removed by the first polishing step using a first slurry containing a first proportion of abrasive material, and a second portion, overlying the dielectric layer, is removed by the second polishing step using a second slurry containing a second proportion of abrasive component, wherein the second proportion is a reduced proportion, i.e., less than the first proportion. In one embodiment, the abrasive particles of the abrasive component are eliminated, and the second slurry is non-abrasive. In this case, it is noted that the second slurry is not a true slurry because the solids content is reduced to zero. However, "slurry" is used herein to encompass this embodiment of the present invention. In addition, the chemical oxidizer of the second slurry may be the same as that of the first slurry.

The second step is carried out to remove completely thin metal layer 39a to define interconnects 38 separated by portions of the third ILD layer 34 and fine pitch dielectric portions 34a as shown in FIG. 4. As shown, the device may be finished with formation of passivation layer 40. Alternatively, it is noted that another dielectric layer may be deposited followed by higher level metal lines and vias. It is also emphasized that while three metal lines are shown in FIG. 4 separated by two fine pitch dielectric portions 34a, a great number of metal lines (e.g., several hundreds) are generally formed in a side-by-side relationship parallel to each other. Accordingly, it is understood that the erosion problem illustrated in connection with FIG. 2 is of particular concern.

While the combination-step CMP process has been described in general terms above, the parameters utilized in connection with a particular embodiment of the present invention are summarized below. While not shown in the drawings, the present CMP process is carried out on a wafer having a plurality of semiconductor die each having a plurality of semiconductor devices.

Process Conditions

| | |
|---------------|--------------|
| Polishing Pad | Rodel IC1400 |
| Arm Pressure | 4 psi |
| Back Pressure | 1 psi |
| Platen Speed | 59 rpm |
| Carrier Speed | 41 rpm |

Slurry compositions and CMP characteristics

| | | |
|----------|--|------------------------|
| (Step 1) | Ammonium Citrate | 0.025M (moles/L) |
| | 1,2,4-triazole | 0.1M |
| | Hydrogen Peroxide | 1% |
| | Cabot WA355 | 3% by weight alumina |
| | pH | 7.5 |
| | Avg. Cu Rate | 3800 (Å/min) |
| | Avg. Dielectric Rate | 150 |
| (Step 2) | Ammonium Citrate | 0.05M |
| | 1,2,4-triazole | 0.16M |
| | Hydrogen Peroxide | 1% |
| | Cabot WA355 | 0.5% by weight alumina |
| | pH | 7.5 |
| | Avg. Cu Rate | 1600 (Å/min) |
| | Avg. Dielectric Rate | 50 |
| | Avg. Ta ₃ N ₅ Rate | 240 |

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

4. Claims 7, 9, 11, 14-16 are rejected under 35 U.S.C. 103(a) as being unpatentable over Watts et al.'748.

Watts et al.'748 has been discussed above, but does not disclose an acid being picolanic acid and other materials such as precipitated silica, bromic acid, anticorrosion agent as set forth in the claims. Please note that Watts'748 further discloses that chemical oxidizer and the abrasive component will change depending upon the particular metallurgy, as is well-known in the art (col. 6, lines 10-15).

While embodiments herein have been described for use
10 with copper, it is well understood that the present invention
may be utilized to CMP other metal materials, such as
tungsten plugs or aluminum lines. In such cases, the chemi-
cal oxidizer and the abrasive component will change
depending upon the particular metallurgy, as is well known
15 in the art. That is, conventional CMP slurries may be utilized
in connection with tungsten or aluminum.

Thus, It would have been obvious to one having ordinary skill in the art at the time the invention was made to have utilized such materials as set forth in the claims, since it has been held to be within the general skill of a worker in the art to select a known material on the basis of its suitability for the intended use as a matter of obvious design choice.

Response to Arguments

5. Applicant's arguments filed June 20, 2005 have been fully considered but they are not persuasive. As indicated in the above rejection, the functional limitations of "wherein said barrier layer ... slurry system" in the article or slurry system claims 1-20 has been given any patentable weight. In the method claims 24-29, the argument is moot because no such limitations were recited.

Conclusion

6. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

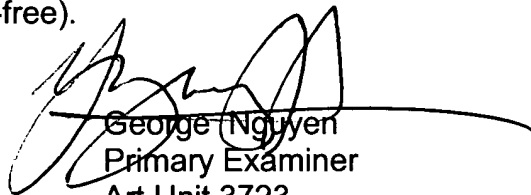
A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to George Nguyen whose telephone number is 571-272-4491. The examiner can normally be reached on Monday-Friday/630AM-300PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Joseph Hail can be reached on 571-272-4485. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

George Nguyen
Primary Examiner



George Nguyen
Primary Examiner
Art Unit 3723

GN – September 06, 2005